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ABSTRACT

This paper examines the role of technology in restructuring education by analyzing how it influences seven important relationships in the educative process: (1) teacher-student relationships; (2) student-content relationships; (3) teacher-content relationships; (4) student-context relationships; (5) teacher-context relationships; (6) content-context relationships; and (7) educational system-environment relationships. After a brief historical overview of the uses of technology in education, the paper discusses the nature of systems in education and examines the process of restructuring through systems change in the seven pairs of relationships as they exist today and as they might change in a restructured educational system. How educational technology can empower teachers and students is then discussed with emphasis on how electronic technology is transforming the way information is communicated and processed. A brief discussion of the role of the teacher in evaluating the worth of content--i.e., selecting the best of culture for sharing with students--concludes the report. (ALF)

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Restructuring Education Through Technology

Theodore W. Frick

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THEODORE W. FRICK

Theodore W. Frick is associate professor in the Department of Instructional Systems Technology, School of Education, Indiana University. He received his Ph.D. from Indiana University in 1984, majoring in educational inquiry methodology, with history and philosophy of science as his minor. While pursuing his graduate studies, Frick was a research associate at the Center for Innovation in Teaching the Handicapped (CITH) for 10 years, where he did R&D on applications of computer and video technology for preservice teacher education.

During his 25 years in education, Frick has been keenly interested in ways of improving learning and teaching. Based largely on his experiences at CITH, he saw the potential of computer technology in education. When he joined the Indiana University faculty in 1983, he began developing a new computer curriculum. He currently teaches graduate courses on computers in education, computer-assisted instruction, and advanced CAI methods. His research has focused on design of adaptive instructional systems mediated by computer technology, which he views as a cornerstone for restructuring education.

He dedicates this fastback to his teachers, Elizabeth Steiner and George Maccia, on whose educational foundations he continues to grow.

Series Editor, Derek L. Burleson

Restructuring Education Through Technology

by
Theodore W. Frick

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Introduction

Scenario 1 (present time). Ms. Dubois, a high school biology teacher, is using a model skeleton to point out the different bones in the human body and their scientific names to the 27 students in her 10th-grade Biology I class, which meets from 10:10 to 11:00 a.m. Most of the students are watching and listening as Ms. Dubois lectures. Some are taking notes. Others are looking at the illustration of the skeleton in their biology textbook as Ms. Dubois points to various bones on the skeleton model. Some Zzz. . .

Scenario 2 (some years later). Ms. Dubois is meeting at 10:25 a.m. in a small conference room with Ben, one of the 72 students in her biology class. She is reviewing the instructional modules he has successfully mastered in the past three weeks. Ben indicates that he wants to study human anatomy during the next three weeks, since he has mastered all the prerequisites. Ms. Dubois electronically copies to Ben's computer disk a list of instructional modules on human anatomy available in the science learning laboratory. She and Ben discuss the order in which he should begin studying the instructional modules.

Meanwhile 24 of the 72 biology students have been working all morning in the science lab on a variety of biology topics they have selected to investigate. A high school senior planning to major in biology in college serves as the media attendant and supervises the lab, while Ms. Dubois meets individually with students to review their progress on their individually tailored educational programs.

At one of the interactive video workstations (a combination of video and computer technology) three students are working together on an instructional module on the human body. This module is a simulation of an emergency room at a hospital. The three students take on the role of a team of physicians. Each time they repeat the simulation, a new person comes to the emergency room with a serious injury or illness. The team's task is to try to identify the patient's problem in order to recommend appropriate medical treatment. If they are right, the patient "lives." If not, they may lose the simulated patient. A real physician on the videodisc provides hints and clues when needed and explains why their diagnoses are on-target or not. These students have at their fingertips an extensive illustrated medical reference also stored on the videodisc, which includes information on muscles, bones, organs, diseases and their symptoms, animations of various systems in the human body, and so on. They frequently consult the references as they proceed through each case. While they realize they are "playing doctor," they are learning a lot about the human body.

These three students have been doing this emergency room simulation for nearly a week. They are now on their 51st case. After working continuously for nearly one and a half hours, they successfully identify this patient's problem. Now that they have progressed this far, the cases are getting much harder. Elated at their success, they then relax by watching a videotape of orthopedic surgery on a motorcycle accident victim. They see some of the same bones they encountered in the medical reference material as they watch the surgeon first look at the X-rays and then insert metal pins into the victim's broken bones to hold them together.

On this morning, the other 48 biology students are learning about ecology firsthand. They are out in the community working on the restoration of a wetlands preserve, a service project the school has undertaken as part of its environmental education program.

Scenario 1 depicts a typical *teacher-student relationship* and a typical *student-content relationship* in high schools today. Scenario 2 depicts

a different kind of student-teacher and student-content relationship, which could exist in a school restructured through technology. How do we get from here to there? In this fastback I examine the role of technology in restructuring education by analyzing how it influences these two essential relationships in the educative process, as well as five other important relationships. To provide perspective, I begin with a brief historical overview of the uses of technology in education.

A Journey from the Past

Technology has significantly transformed education at several major turning points in our history. In the broadest sense, the first technology was the primitive modes of communication used by prehistoric people before the development of spoken language. Mime, gestures, grunts, and drawing of figures in the sand with a stick were methods used to communicate — yes, even to educate. Even without speech, these prehistoric people were able to teach their young how to catch animals for food, what animals to avoid, which vegetation was good to eat and which was poisonous.

As these primitive modes of communication evolved into spoken language, a second major technological breakthrough occurred. Knowing how to speak and understand a language allowed people to educate the young through story telling. Through stories and drama the older generation could communicate their accumulated knowledge and experiences to the younger generation, who in turn would remember the stories and then tell them to their children. It might be fair to say that spoken language restructured educational practices thousands of years ago.

The next major technological breakthrough was written language. Cave paintings evolved into symbols, since abstract ideas were difficult to portray iconically or through drama. And these ideas could be recorded as symbols on stone tablets. Clearly educational practice was transformed by writing and reading. Students could learn through

reading the symbols on the stone tablets. And most important, human experiences could be preserved from generation to generation on the stone tablets without relying solely on memory.

The advent of parchment, papyrus, and paper was also an advancement in technology. Heavy stone tablets were difficult to carry long distances, so recorded information was not very portable. With parchment scrolls, scholars could now carry their information with them and could look up things they had forgotten. And scribes could write on scrolls with ink much faster than chipping away on stone tablets. Again, technology improved communication; and what was known could be disseminated further and faster to more people.

Only a few centuries ago the printing press was invented. This heralded a dramatic transformation in educational practice. Students no longer had to copy down everything the teacher said (or read aloud from scrolls). Reading from scrolls changed to reading from books — lots and lots of books. No doubt some eager students suffered from “information overload” with all the books coming off the printing presses. Through books the accumulated knowledge could reach many more students, not just a select few from the wealthy class who could afford private tutors to educate their children. Students no longer had to sit in the presence of the teacher in order to learn. They could read the book. Textbooks were invented. And so was homework.

And it was only a few decades ago that electricity began to transform the ways in which information was transmitted. Radio was invented, then television, then the computer. Information in audiovisual form could be recorded, played back, or transmitted electronically. Now we can watch videotapes in our homes. The tapes are often cheaper than books and much easier to copy. Students do not have to be there when an event happens. A teacher demonstration or a school play can be videotaped and students can view it at their leisure. They can play the tape over and over if necessary. They also can watch the 6 o'clock news and simultaneously tape Bill Moyers' documentary for later viewing.

Television has transformed education — although not necessarily in ways that educators would approve. Television is a new teacher that communicates messages worldwide through images and sound. Smell, taste, and touch are missing, but the messages are still more vivid than the static printed word. Talk about potential for influence.

Meanwhile, public schools are still waking up to the fact that television's new teachers have taken over. These teachers may not have the proper credentials, but they are influencing — yes, educating — our youth. Ask young people who Michael Jordan is, or Michael Jackson, or Madonna, then look at what they are wearing on their feet or watching on MTV. This is the generation brought up on *Sesame Street*.

Some may take exception to my claim that Michael Jordan, Michael Jackson, and Madonna are some of our new "teachers." Clearly, they are not school teachers. But that is my point. Schooling is a narrow conception of education. Schools are one way of educating but certainly not the only way. Madonna is a teacher and her "students" are all those who follow her music and watch her videos. She's sending out a message — brass brassiere and all — a message of sexuality and rebellion; and lots of our younger generation are getting it. We may not like her music or her message, but that's beside the point. She has been smart enough to take advantage of the technological revolution that has transformed communication. She has outfoxed us educators. Technology is transforming education right before our eyes.

I'm a teacher, too, and fall somewhere in time between Socrates and Madonna. At least I have adapted to the computer age, the latest form of technology to transform education. As I sit at my home computer, I realize that it is a far cry from carving on tablets or painting on cave walls. For example, I recently sent electronic mail copies of a four-page paper to several colleagues. And with a push of a button on my keyboard, I can send my "paper" all over the world through a series of computer networks. Still, I can't help but wonder why I am sitting here making symbolic scribbles of light by tapping on keys,

which will be run out in text, then printed by a press on paper and distributed as a small, inexpensive booklet called a fastback. I'm thinking interactive video would be a much more effective way to get my message across. Maybe I should take lessons from Madonna and Michael. But here goes — in print.

Red rover, red rover,
Madonna move over!
Ready or not,
Here we come.

Education and Educational Systems

My thinking about the role of technology in restructuring education has been shaped by what I learned from one my professors, a wise and caring educational philosopher named Elizabeth Steiner. She contends that the essence of education consists of teachers, students, content, and contexts. For education to occur there must be a teacher who guides, a student who intends to learn, content to be learned, and a context or setting in which the guidance and learning occur. Education also occurs in an environment consisting of the surrounding community and its culture. Let me elaborate on each of these essential elements of education, which will serve as a preface to my ideas about the role of technology in restructuring education.

Education cannot occur without a teacher. A teacher is one who guides or leads. To guide does not necessarily mean to instruct directly. We often think of teaching as direct instruction (presenting information, asking questions, giving feedback, demonstrating some procedure, evaluating student progress, and so on). But a teacher can guide without instructing directly. A good example is the Montessori system of education. In a Montessori school, most of what a child learns is through interacting with a variety of curriculum materials in a particular context. A Montessori teacher does much less direct instruction than do teachers in traditional schools.

I'm a college professor and I teach classes, but it took me a long time to realize that much of the teaching I do is outside the class-

room. Students come to my office with questions or asking for advice, or they send me E-Mail that I can read and reply to at my home, or they call me on the phone. I often respond by suggesting sources of information, such as books, manuals, and computer programs, or by referring them to more advanced students. I loan out lots of my own books, papers that I or others have written, and my computer files. I often find myself saying, "Read this or do this learning activity on your own and then come back and we'll talk some more."

Even though I teach only one or two formal classes a day, I spend a great deal of my waking hours interacting with students who want my advice and guidance. Only about half of that interaction is face-to-face in the classroom, in my office, and in the halls. The rest is mediated by electricity — some by telephone, quite a bit by E-Mail these days, and yes, still a good deal by print on paper. In short, much of my work as a teacher does not involve direct instruction.

Education cannot occur without a student who intends to learn. According to Steiner, if a student does not intend to learn, then no education is going on. A student's mere presence in a classroom is no guarantee that education is occurring. There has to be an intent to learn, which is facilitated by the guidance of a teacher. But this guidance does not have to involve face-to-face contact, nor does it need to occur in a classroom.

Education cannot occur without content. The content is what is shared between successive generations. Students must interact with content in order to construct understandings and their personal values and beliefs. Content is not just math, English, or biology. And content is not found in books or computer programs or on the television screen either. Content is the stuff of human thoughts, ideas, aspirations, feelings, and attitudes. What is found in media such as books and TV are representations of content. The content may be symbolically coded in language only, or it may be conveyed through drama, for example.

Education cannot occur without a context for teaching and learning. The context for education is much broader than the schools. For example, education occurs in the context of the home, where some of what is learned may not be necessarily good. But nothing in the definition of education says it has to be good. Another context for education is found in our inner cities where youth organizations such as the Boy's Club, Girl's Club, YMCA, and YWCA are providing valuable learning experiences for youngsters from destitute families, broken families, or no families. Staff working in these organizations may not consider themselves educators, but they are. And the youngsters who go to these youth organizations do so voluntarily. They want to be there; in some cases they have to earn their way in by getting off drugs. These youth organizations are one example of restructured "schools"; they clearly are an educational system, one quite different from the public school system.

Education occurs in an environment consisting of the surrounding community and its culture. The environment surrounding the educational system operated by the inner-city youth organizations can be quite depressing. Streets are unsafe, parents are often gone when their children return home, siblings may be drunk or drugged, and pushers drive Mercedes. This is a grim environment in which the youth organization educational systems operate, but an environment nonetheless. There is a grim environment, too, in some of the homes in wealthy suburban areas, where the needs of children are ignored, where consumption becomes the most important thing in life, and where success means earning lots of money. There are, of course, healthy environments in the inner cities, in the suburbs, and in rural areas, where parents care about their children and their futures and where a lot of good nurturing is occurring outside of school.

When education is perceived in terms of the essential components described above, it is clear that we are talking about more than what occurs in our school systems. There are, in fact, many systems. So now let us turn to the idea of systems in education.

The Nature of Systems in Education

The concept of *systems* is really quite simple. The basic idea is that a system has parts that fit together to make a whole; but where it gets complicated — and interesting — is how those parts are connected or related to each other. There are many kinds of systems: government systems, health systems, military systems, business systems, and educational systems, to name a few. As we shall see, the concept of system becomes a powerful metaphor when thinking about the role of technology in education.

When we speak of an educational system, the first thing we need to do is to expand our mind-set, just as we did in defining education as broader than schooling. Customarily we think of an educational system as a school district consisting of teachers, administrators, and students in a number of school buildings in a particular community. But this is only one way that an educational system can be physically structured and organized.

Another way to think about an educational system is to take the four essential components of education described earlier (teachers, students, content, and contexts) and then examine the relationships among these four components. Using a systems approach, I find six kinds of relationships among the four components:

1. Teacher-student relationships
2. Student-content relationships
3. Teacher-content relationships
4. Student-context relationships
5. Teacher-context relationships
6. Content-context relationships

A seventh and very important relationship is that between the educational system and its environment.

When we talk about restructuring schools through technology, we should be concerned with the kinds of changes that might be made

in one or more of the seven basic relationships in an educational system as described above. In the next chapter we shall examine some examples of how technology can change the seven relationships in our systems model.

Restructuring Through Systems Change

The systems model proposed here can serve as a framework for thinking about typical examples of relationships in current educational systems. In the following sections, the seven pairs of relationships are considered. I first list examples of typical relationships that now occur in schools, followed by a section titled "What if," in which I discuss some possible ways these relationships might change in a restructured educational system. My intent here is not to forecast or suggest changes that will, or ought to, occur but rather to stimulate your thinking about possibilities.

Teacher-Student Relationships

Now

- Teachers present information orally and visually to groups of students.
- Teachers assign the same readings and exercises to an entire group of students.
- Teachers grade students' homework and tests and provide feedback on their progress.
- Teachers supervise student seatwork when not directing group activities in the classroom.
- Teachers answer students' questions.
- Teachers seldom individualize instruction because it is impractical under current conditions.

- Teachers discipline students who misbehave.
- Students ask teachers questions when they do not understand some learning task.
- Students listen to teacher lectures and watch demonstrations.
- Teachers usually select the content to be learned and decide how long students should take to learn it.
- Most communication between students and teachers is face-to-face and to a lesser extent by writing.
- Teachers and students typically spend a limited amount of time together in a teaching-learning relationship, usually an academic year (9 to 10 months).

What If

How might the relationship between teachers and students change in a restructured educational system? If electronic information technologies were used to deliver instruction to students (computer-based tutorials, simulations, guided-practice exercises, interactive video, hypermedia), then several basic changes could take place. First, a student would have a multitude of teachers, not just one or a few at some point in time. Each of those teachers would be communicating with students via the technology as authors of computer-based learning materials in which information is presented, appropriate interactive tasks with feedback are provided, and achievement is assessed. Thus, much of the interaction between teachers and students would be indirect, not face-to-face.

On the other hand, a student's "executive" teacher could establish a more individualized relationship with each student. By being freed from the role of information provider to groups of students, the executive teacher would then have more time to establish an individual plan of instruction with each student. The executive teacher would be more like a manager of a student's learning experiences by being available to answer students' questions or by dealing with content and feedback not adequately presented in the technology-mediated learning experiences. The executive teacher might also have more

time to get to know students personally and listen to what is on their minds.

Student-Content Relationships

Now

- Students too often find subject matter to be meaningless, disconnected from real life.
- Student interaction with content is mostly passive (listening, reading, or watching).
- Students most often must deal with content that is abstract or in symbolic form (written/spoken words) and less often with content that is in iconic, representational, or concrete form.
- Students encounter content that typically is static, not changing as knowledge or events change.
- Students seldom choose what content to learn, when to learn it, how long to spend on it, or how deeply to delve into it.
- Many students fail to master learning objectives since the rate of learning is externally paced much of the time.
- Many students are bored with, or alienated from, the subject matter they are expected to learn.

What If

How might the relationship between students and content change in a restructured educational system? Compared to reading a textbook, students would become more actively engaged in learning by interacting with technology-mediated learning materials. Such materials, if well designed, would give students numerous opportunities to respond and would provide immediate feedback in the form of corrections or additional information. During computer-based simulations, feedback would occur when a student experiences the consequences of his or her actions. Students would have more control over the pace of their learning and spend as much time as needed to master particular learning objectives. The decision of when to move

on to subsequent objectives would not be determined by the average group achievement but rather by the individual student's progress. Students actively engaged with content and experiencing success with it would be more enthusiastic about the subject matter they are studying. Finally, when the content is technology mediated, it becomes possible to present it more dynamically in aural and visual modalities using interactive video.

Teacher-Content Relationships

Now

- Teachers have learned most of the content they teach during their formal education in college but are mostly on their own with regard to further learning once they are in the classroom.
- Teachers' past relationships with content are similar to those described above for students and are subject to the same limitations.
- Teachers have little control over what content is to be covered and when. Such control rests primarily with textbook publishers and with state and local curriculum guidelines.
- Teachers most often are required to use externally produced learning materials, such as textbooks, workbooks, films, videotapes, and computer courseware.

What If

Teachers would be able to further their own learning by using the same kinds of technology-mediated materials as students use. Teachers would be able to design and produce instructional materials themselves using computer-based authoring systems, desk-top publishing, video technology, and so forth. Teachers would be developing some of the content for their classes rather than relying almost exclusively on externally produced materials.

Student-Context Relationships

Now

- Students attend class in separate rooms, usually in a large building with hundreds of other students.
- Students spend most of their time in school with a group of other students who are in the same grade and are about the same age.
- Schedules, bells, and the school calendar dictate the teaching-learning process. Students attend 40- to 50-minute classes, five days a week for 180 days a year. Little organized learning goes on in the late afternoon, evenings, on weekends, or during the summer.
- Students spend a considerable amount of their time reading printed material and writing about what they have read.
- Students typically sit at desks oriented toward the front of the room.
- Secondary students have little private storage space for personal effects except for a locker in the hall.
- Students tend to be isolated from the rest of the world while in school — from the community, from telephones, and from computer networks.

What If

Since information technology can bring many more teachers to a student, there would be no need to continue the large, consolidated schools that have become prevalent in the U.S. The original argument for consolidation, particularly at the secondary level, was to support a broader curriculum offering more specialized courses, such as advanced mathematics, science, and foreign languages. Returning to the small neighborhood school would be possible and practical. Teachers of specialized subjects can "travel" electronically to the neighborhood schools.

Modern educational technologies make individualization of instruction truly possible for the first time. There would be no need

to continue the lock-step system of grade levels — nor ability grouping — since a teacher would not need to teach to the middle of the group. If a mastery learning approach is adopted, then different students would learn at different paces; mixed-age groups would become possible. The goal would not be promotion to the next grade but rather the mastery of educational objectives by each student. The drudgery of record keeping as well as some forms of achievement assessment could be handled by computers. The report card could be replaced by a computer disk containing a detailed history of each student's progress; and it could be accessible to the teacher, the student, and parents — at any time.

A student's desk could be replaced by a computer workstation connected to a computer network in the local school system, which in turn could be linked to other networks around the world. There is no reason why these interactive workstations need to be located in conventional classrooms. It might make more sense to cluster workstations in terms of function (interactive video, word processing, information searching), where the hardware needs will vary.

Currently schools have few secure places for students to put their things — textbooks, notebooks, and personal effects. How can students feel like they belong if the facility has no designated places for them to put their own stuff? In most homes, parents and children have some space that is their own. It is certainly feasible for each student to have his or her own computer system at school, accessible at all reasonable hours, year round. Furthermore, students could take portable computer systems home. For years they have taken textbooks home to study. Why not their portable computers? Or why not computer terminals at home for access to school computers? Certainly some specialized computer systems will need to be shared by numerous students. However, private storage space can be made available on these systems so each student has a place to put his or her projects, "papers," notes, electronic mail messages, etc.

Finally, one further change that could occur, particularly with older students, is that they would not have to be in school in order to

get an education. Their learning could occur at home if they had access to computer technology and appropriate learning modules. Lord Walter Perry, former vice-chancellor and one of the founders of the Open University in Great Britain, predicts that in the 21st century we will be forced into this kind of home learning, because it will become too expensive to transport students to school on a regular basis.

Teacher-Context Relationships

Now

- Teachers work in a classroom, typically one teacher to a room with from 20 to 30 students at any given time.
- Teachers, by and large, are isolated from the rest of the world while at work in the classroom.
- Teachers have limited opportunities to discuss their work with colleagues.
- Teachers usually present information by using chalkboards and overhead projectors.
- Teachers mark students' work by writing corrections and comments in red ink on their papers.
- Teachers often spend time at home — outside of regular school hours — preparing lessons and grading student homework and tests.
- Teachers seldom work with students outside the school setting — at home or in the community.
- Teachers typically have little private storage space, beyond a desk in a classroom, for keeping learning materials and other professional materials. In essence a teacher's "office" is the classroom.

What If

One significant change is that teachers could become technologically linked to the rest of the world. They could access information electronically. They could communicate with each other as well as

with students and parents using E-Mail. Teachers could instruct from their own homes using computer and telephone networks to students' homes. Audio-graphic technology would allow live interaction between teachers and students. The sound would come through telephone speakers; and students would see text and graphics on their computer screen, which becomes the teacher's electronic chalkboard, so to speak. And most important, each teacher would have his or her own computer system, plus a telephone for sending and receiving voice mail.

Content-Context Relationships

Now

- Much content is embodied in print format in texts, workbooks, dictionaries, encyclopedias, and periodicals.
- Much content is static and is slow to change, even after knowledge changes.
- Much content is presented in a verbal, abstract form — less often in iconic, representational, or concrete formats.

What If

Content could be presented in a variety of formats via multi-media. Dynamic processes could be illustrated. Content in the form of text, still pictures, video, sound, graphics, or animations could be digitally or analogically encoded and stored in electronic, magnetic, and optical technologies. This encoded information could be transmitted literally around the world in a matter of seconds. The electronic global village that Marshall McLuhan envisioned is now a reality, as dramatically illustrated recently by the CNN World News live coverage of the Persian Gulf War.

Educational System-Environment Relationships

Now

- Parents or other community members have little communication with or participation in teaching-learning experiences in school.
- Students and teachers have to go to school in order to engage in learning experiences.
- Students attend school for only a limited period (not in evenings, on weekends, during summers); many are bused; and all come and go at basically the same times.
- Most formal educational activities occur in schools, not out in the community.
- Public schools serve students between the ages of 5 and 18, but most of the rest of the community is excluded from participation in formal education.
- Teachers are certified and licensed by state agencies.
- School boards, elected by the local community, monitor the administration and operation of the educational system.
- Curriculum materials are selected primarily from those produced by commercial publishers.
- Educational systems have few communication links with the outside world, such as computer networks and TV cable or satellite access.
- Educational systems are highly centralized, making it difficult for community members to have much direct influence on what happens in the system.

What If

In the future, telecommunications technologies could significantly alter the kinds of relationships between educational systems and their environments. As a result of consolidation, U.S. school systems have become rather large and highly centralized. This requires students to be bused to and from school on strict time schedules. Telecommu-

nications technologies could change this, making educational systems much more open and flexible. School districts could become less centralized, with more smaller neighborhood schools. Some aspects of formal education also could be carried out in the home setting or other non-school settings in the community. And community resource people could be "brought in" to the classroom via telecommunications. In a restructured educational system, there could be a greater variety of "teachers." The educational resources of the system could be used by community members during evenings and on weekends.

There are many ways that educational systems could be restructured. In the discussion thus far, I have attempted to show one way, using basic concepts from general systems theory (system, components, component relationships, system environment) and from educational theory (teacher, student, content, context). I identified seven fundamental kinds of relationships that exemplify those basic concepts from systems theory and educational theory and then listed a few examples of how technology could significantly change those relationships, thus leading to educational restructuring. I don't know how things will turn out, but I strongly believe that teachers should be leading the change. And I am not referring just to school teachers, but to all teachers.

Red Rover, Red Rover,
Madonna come over.
We need your help, too.

Educational Technology Can Empower Teachers and Students

In my brief history of technology, I pointed out how technology changes what teachers and students can do. Ancient teachers took their students to the cave to see the drawings. Then came carved stone tablets carrying important information. Next came writing on paper. Plato the philosopher was able to use the technology of writing on paper to share his wisdom and that of his teacher, Socrates, with generations of humankind over the last 2,400 years.

Here I am trying to do the same thing, in the same medium. But instead of pen and paper, I have a computer to help do my writing. In fact, I have my own "printing press" in the form of desk-top publishing. I seldom carry books back and forth from my office to home. Often I just stick a floppy disk into my shirt pocket. Increasingly, I don't even carry a disk along, because I have transmitted the information electronically to somewhere I can access from my office and home. And so can my students. I put documents and software that my former students and I have written on a computer system, which my current students can access through a computer network. I seldom give paper hand-outs but instead tell students the name and location of the computer file, which they can then access to read or make a paper copy to read, or if they prefer, to copy electronically onto their own floppy disk.

We teachers and students no longer need to lug around heavy stone tablets, or armloads of scrolls, or stacks of books. All we need to

do is "plug into" the world of electronic information. We need to be carrying around our personal computers and video cameras and creating our own interactive video instruction. An electronically mediated, two-way conversation can now go on between student and teacher. Our students can now send messages to the medium and in turn receive messages. The medium has become a two-way street. Computers and video are our new chisel and tablet, our new pen and paper, our new chalk and eraser, our new textbook.

This electronic technology is transforming how information is communicated. New teachers are learning how to use it effectively. They are using technology to empower themselves. However, many teachers are not yet comfortable with technology of the kind we are discussing here. They are concerned that their role will be taken over by machines. Let me put such concerns to rest. Don't worry, there is no HAL (the intelligent computer in the film, *2001: A Space Odyssey*). Remember that electronic media are just that. They convey messages. It is we teachers who must supply the content of those messages. That has always been our role, though some of us may have forgotten it because of the dominance of textbooks in our current system of schooling.

While computers are very good at certain tasks, such as diagnosing equipment malfunctions or performing mathematical functions, they are morons at doing things your dog or cat can do, such as recognizing you and acknowledging your presence. Computers lack qualitative intelligence, that is, the ability to identify those features that make each of us unique and different. They also are limited at doing innovative and creative things; they lack inventive intelligence. While computers can generate some visual art and music, they cannot tell you if it is any good; they cannot appreciate or evaluate.

A phrase used by people who work with computers is "garbage in, garbage out." There is a lot of wisdom in that phrase. Computer systems blindly manipulate symbol systems, images, sounds, icons, and the like with no cognition of their meaning. For example, the word-

processing program I am now using has no idea whatsoever what I am typing. It merely processes the symbols I strike on the keyboard and follows my directions for editing. There is no question but that this software program significantly empowers me when it comes to writing. But it does not know what I mean by the words I choose for expressing my ideas. The same is true for computer-assisted instruction, whether it is drill-and-practice, simulations, interactive video, games, tutorials, or hypermedia. The computer software has no idea of the messages being sent back and forth between teachers and students. Still, the computer software can empower both our ability to teach and to learn.

Sharing the Best of Culture

The personal computer and video camcorder have been with us for about only a decade — a tiny moment in time when we consider the thousands of years over which technology has evolved. Still, in just that flick of time, this technology has begun to transform the education process, even as we are transforming the technology.

The technological tools available today for creating computer-based learning materials are incredibly more powerful than those introduced just a few years ago. We can make our own movies with camcorders in our homes; we can publish our own books. Soon teachers and students will be able to use computer-video technology to produce their own learning materials. All it takes is time, know-how, and some funds.

However, the technology cannot select the best of our culture for sharing with students. The technology is incapable of doing that. It cannot tell right from wrong. It cannot distinguish opinion from truth. It cannot appreciate beauty. In short, the new technology cannot evaluate the worth of the content that we embody in the medium. That is our essential role as teachers. We must select the best of culture and share it with the next generation. Let us never forget it.

As Alan Kay has said, "The best way to predict the future is to make it." The future is in your hands, and you have some powerful tools to help mold it.

Red Rover, Red Rover,
Let technology come over.
Ready or not,
Here it comes!

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